An Operational Geospace Model at the National Weather Service: Latest Update

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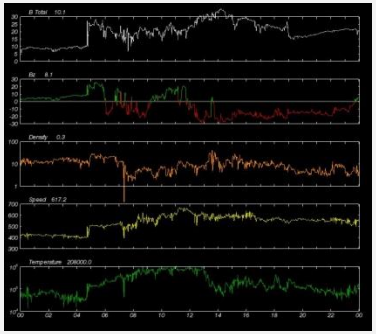
The National Centers for Environmental Prediction (NCEP) a part of the National Weather Service: "..the starting point for nearly all weather forecasts in the US"

- Global Observations
- Operational computer modeling / Data Assimilation
- Post-Processing / Reforecasts

Geomagnetic Activity Prediction :

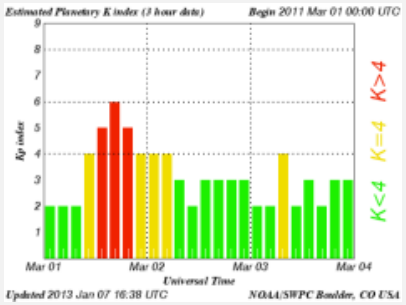
CURRENT CAPABILITY

Satellite measurements of Solar Wind



Simple empirical relationships / neural networks etc.

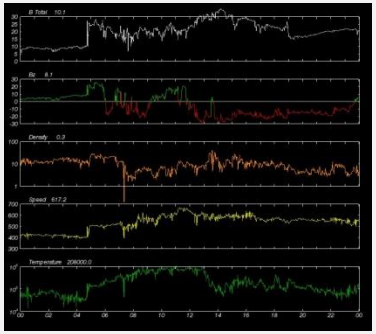
Forecast of Geomagnetic activity: single value for the whole planet



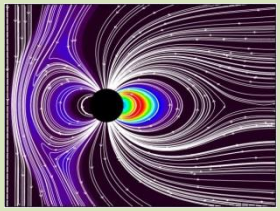
Geomagnetic Activity Prediction :

PROPOSED SYSTEM

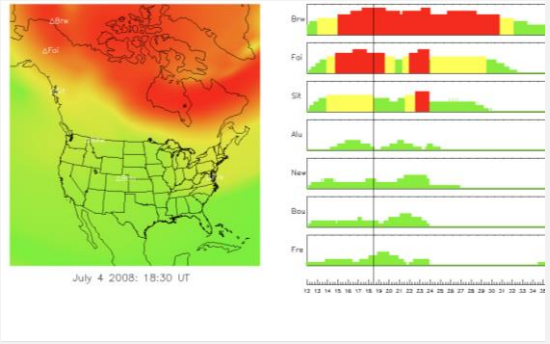
Satellite measurements of Solar Wind



Sophisticated 3D model of Solar Wind-Magnetosphere running on WCOSS

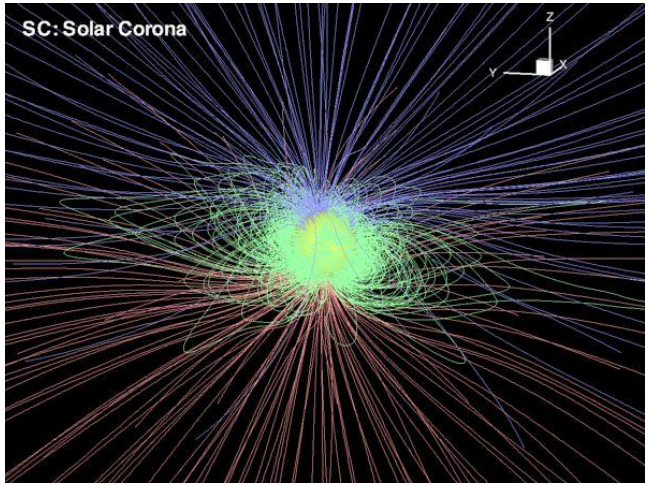


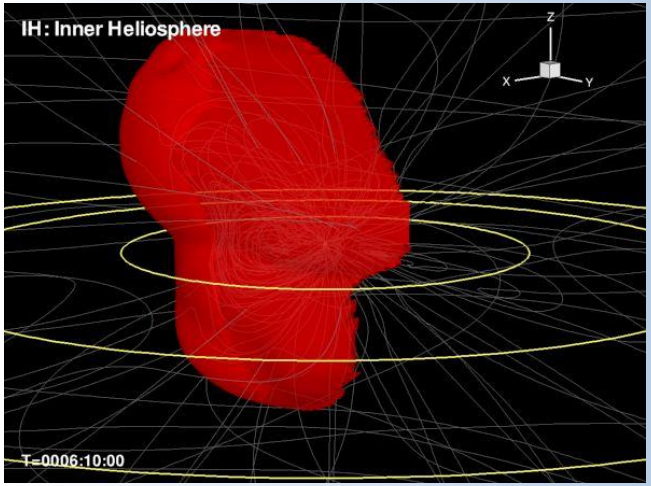
Forecast of Geomagnetic activity as a global map



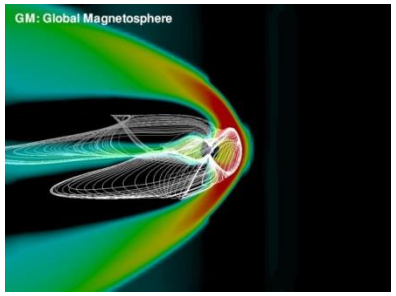
Space Weather Modeling Framework SWMF:

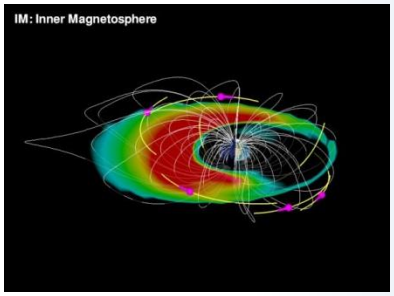
- Developed at the University of Michigan, Ann Arbor
- Comprehensive, 3D, time-dependent, physics-based, first principles model(s)
- Components can be combined together within the common “framework” (examples: Solar Corona, Inner Heliosphere)

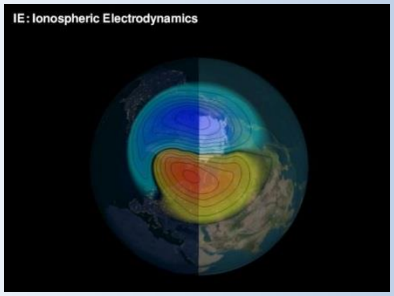




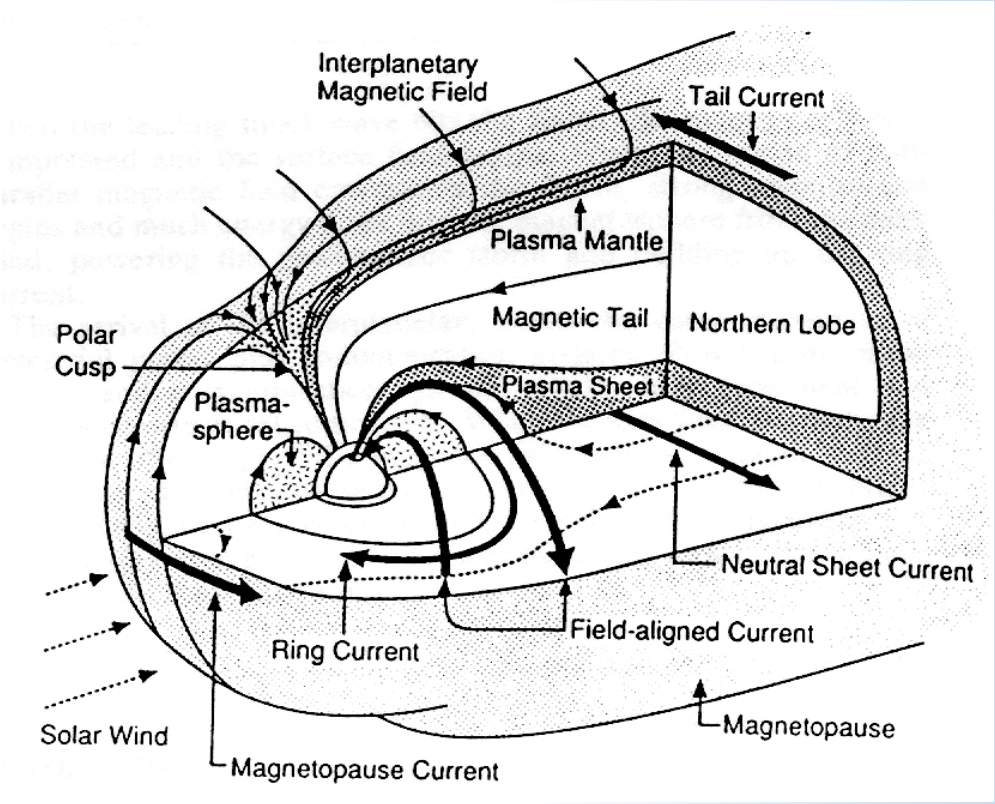
(essentially like the Enlil model)







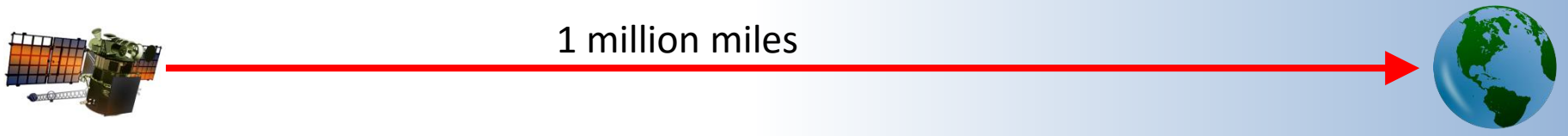
Several contributing current systems: Magnetopause, field-aligned, Ring Current, Ionospheric Pederson and Hall Currents:



Spatial and time-varying dB on the ground calculated via Biot-Savart integration.

Running a Geospace model as an operational forecast model : Essential Points :

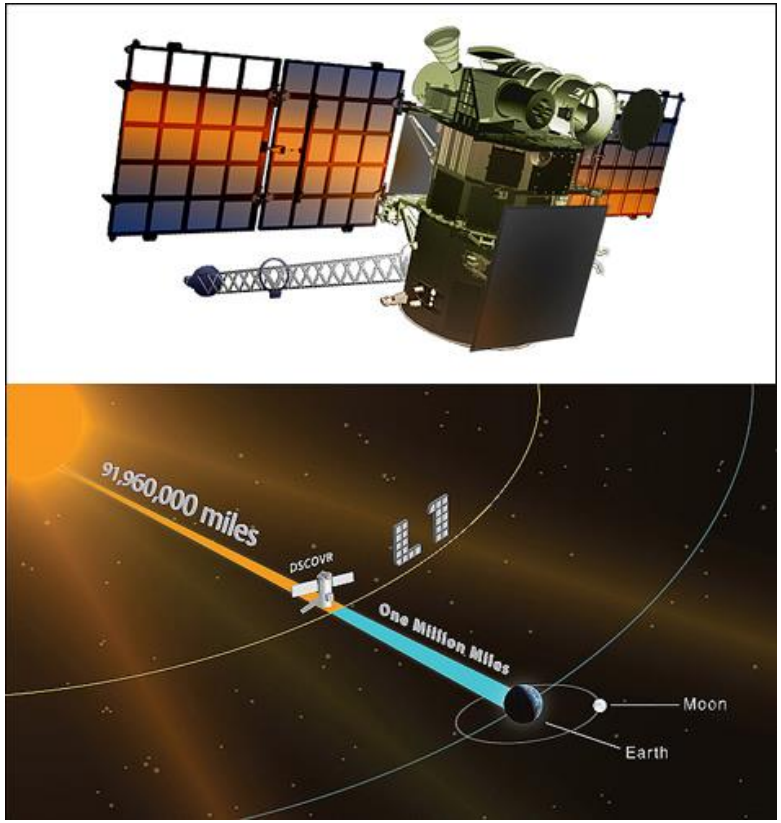
- The magnetosphere is fundamentally a system driven by the Solar Wind
- The model does not “run into the future” (in a traditional weather model sense) – it just steps along in time with it’s Solar Wind input.
- Forecasting ability comes because the SW is measured 1 million miles upstream, at L1 – propagated forwards in time to the position of Earth

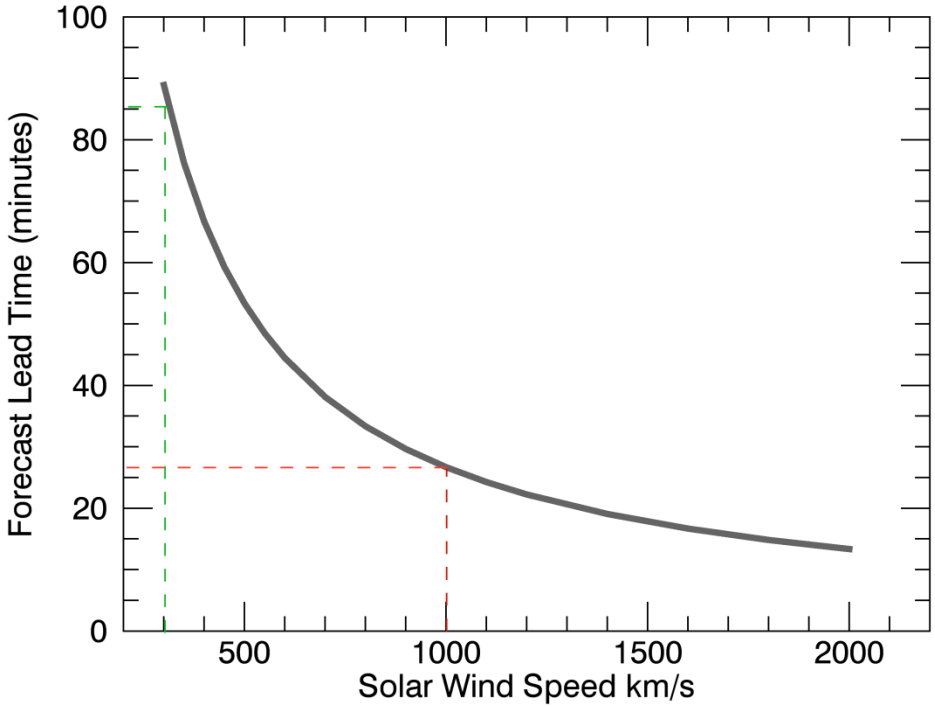


- Forecast lead time is dependent upon incoming SW speed
- Geospace model needs to run in Real-time (a paradigm shift for the NWS ops computer)
- Sharp jump upwards in SW speed (ie, incoming CME) – model has to ***STOP and RESTART*** from a previous point consistent with the new SW data.

In situ measurements: 92,000,000 miles downstream from the Sun
1,000,000 miles upstream from Earth

ACE(1997) → DSCOVR(2016) :: Operational Sentinels at L1





Fast incoming CMEs (say, >1000 km/s), Forecast lead time is less than 30 minutes

Timeline to Operations……

- 2013: SWPC and NASA-CCMC - evaluation of suitable Magnetospheric models [in coordination with the modelers themselves]. Metrics: model skill scores for predicting dB/dt, regional K value, compared to 3 chains of magnetometers (east/West US and Europe). 6 magnetic storms evaluated. 2 reports prepared by CCMC (dB/dt | regional K)

- 2014: Space Weather Modeling Framework (SWMF), University of Michigan, chosen by SWPC as best performing – mature enough to provide significant advance in Geomagnetic forecasting.

- 2014/2015: SWPC worked closely with model developers at UMICH to facilitate model changes needed for real-time operations.

- January 2016: Full v1 test system handed to NCO for operational implementation

- March 15, 2016: NCEP 30 day evaluation initiated. Model system proved robust [performed correctly during SWPC switch to APS backup, Solar wind data dropouts, WCOSS computer switch, GYRE -> TIDE]. Real-time test products viewable by SWFO forecasters. Test completed, April 14. Model still running.

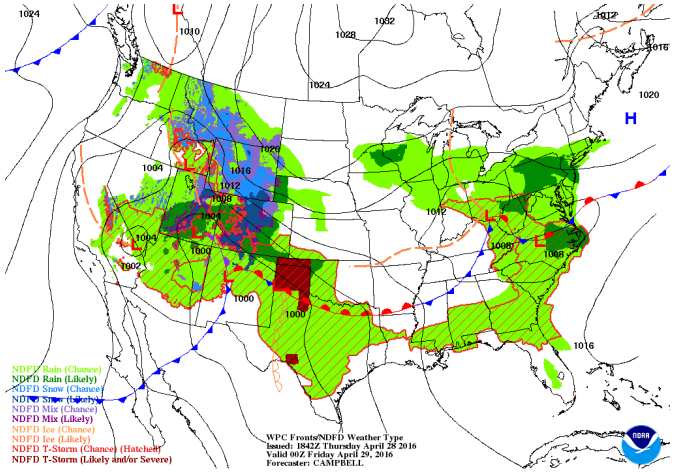
- April -> October: Ongoing development of initial products and operational database.

- October 1, 2016: Formal Operations (forecast products for SWFO and public)

Comparison of Operational Models on WCOSS (ie, We are Modest)

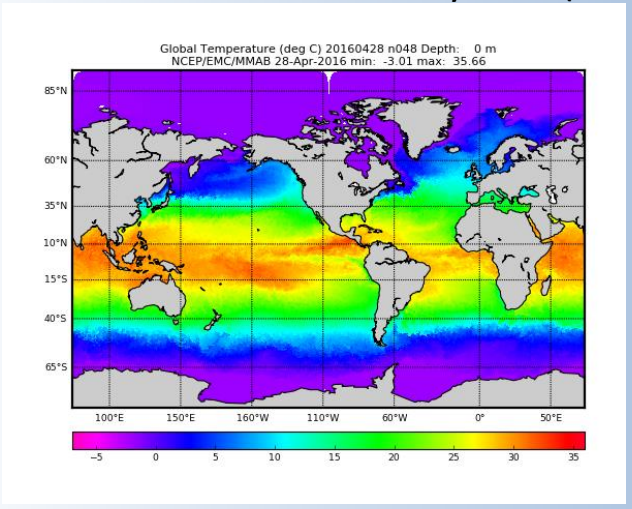
The 2 big ones:

North American Mesoscale (NAM)



2672 processors

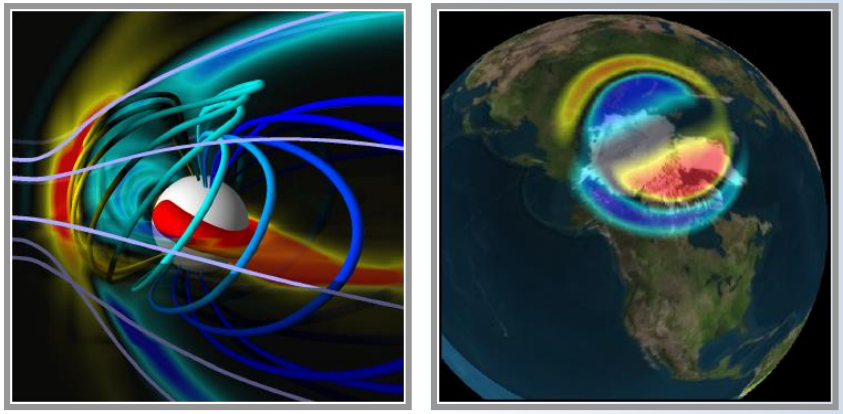
Real Time Ocean Forecast System (RTOFS



2034 processors

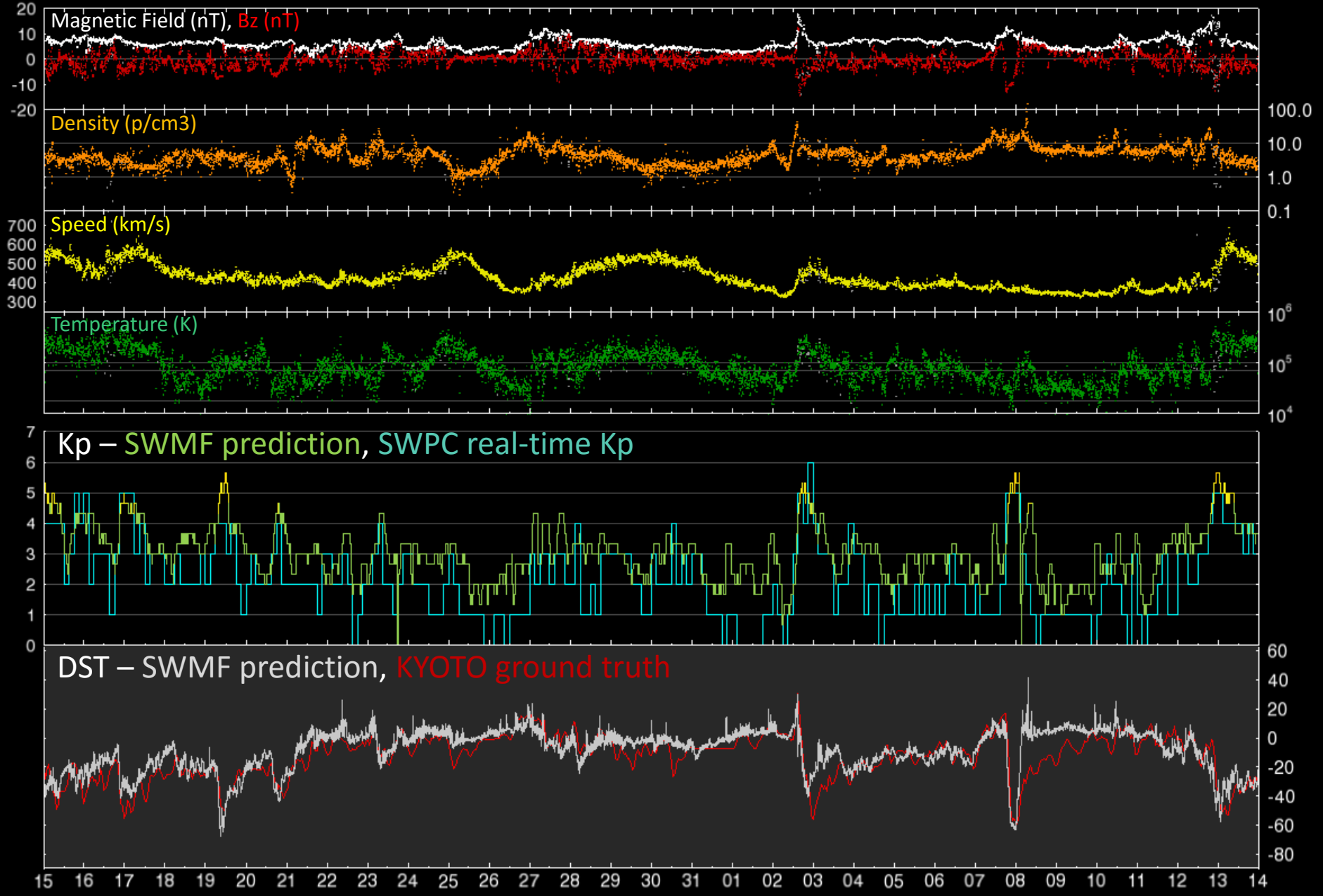
Us:

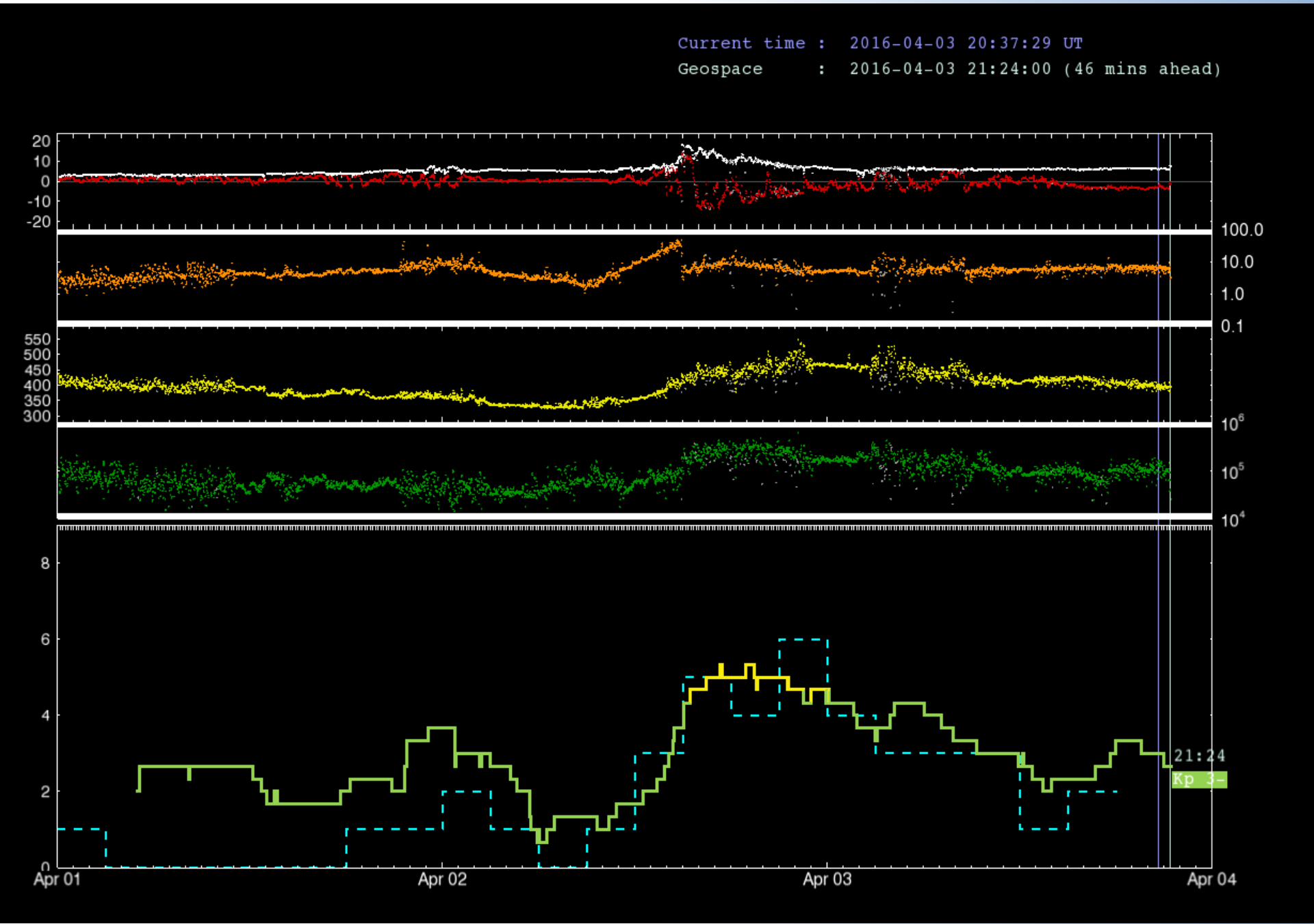
Geospace (SWMF)

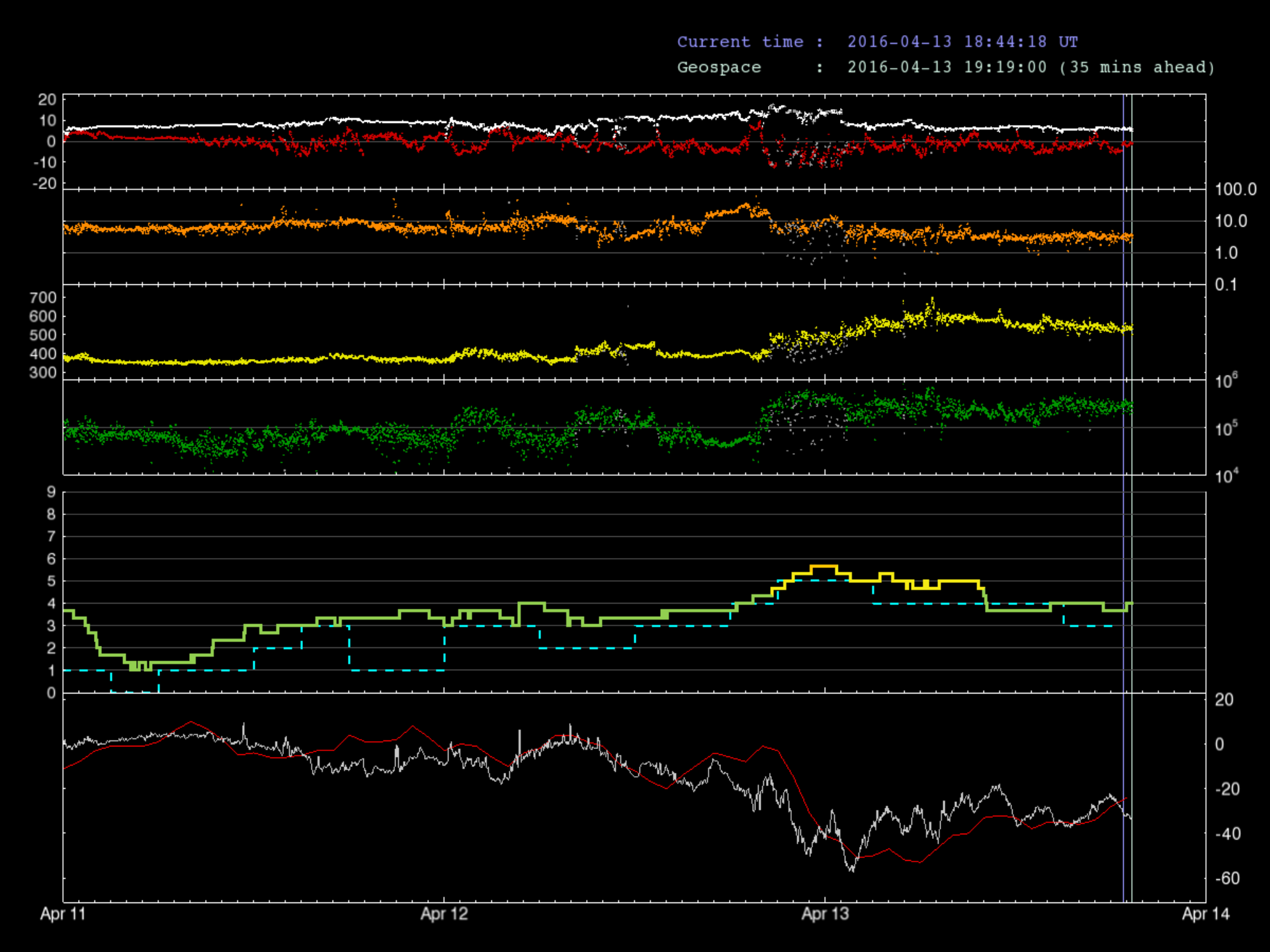


144 processors

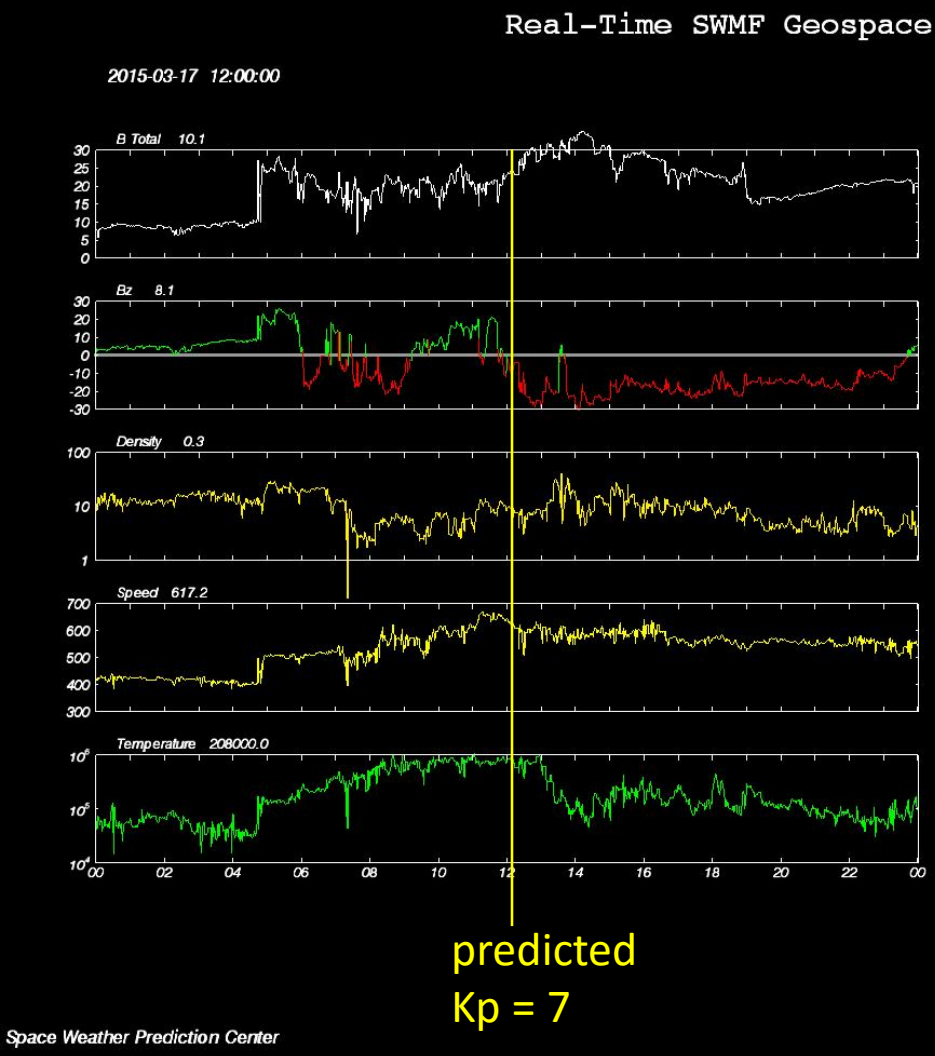
30 Day Model Evaluation: Overview

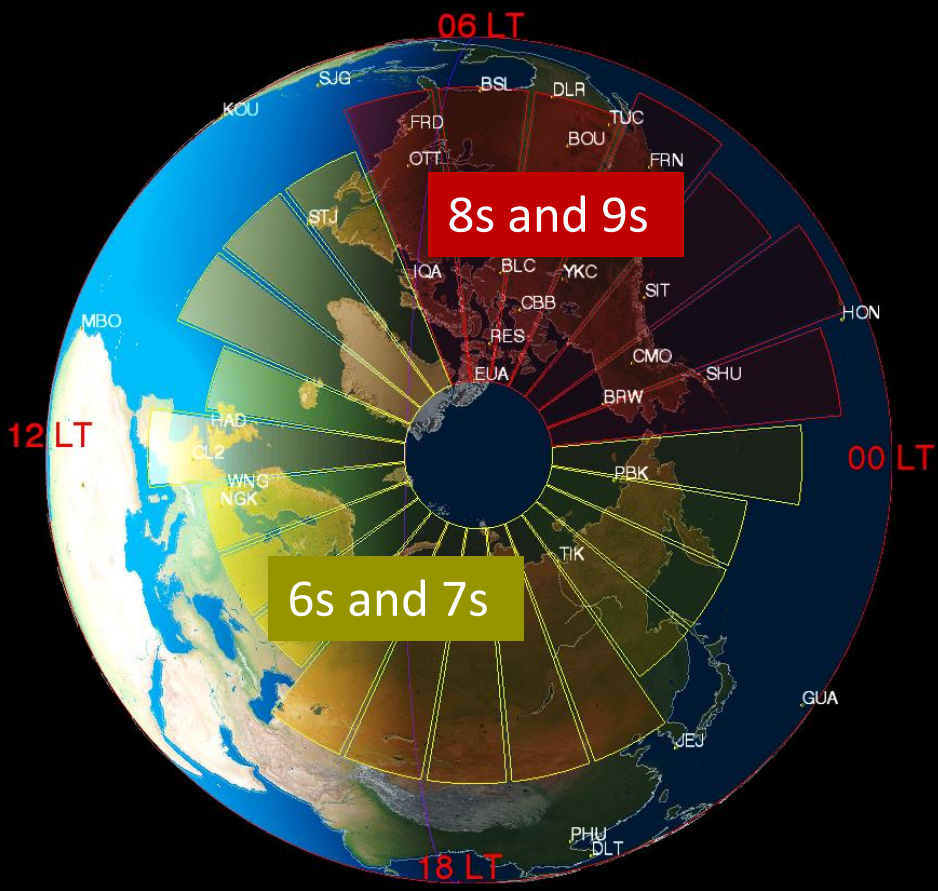



Current time : 2016-04-03 20:37:29 UT
Geospace : 2016-04-03 21:24:00 (46 mins ahead)
20
10
0
-10
-20
100.0
10.0
1.0
0.1
550
500
450
400
350
300
10^6
10^5
10^4
8
6
4
2
0
21:24
Kp 3-
Apr 01
Apr 02
Apr 03
Apr 04

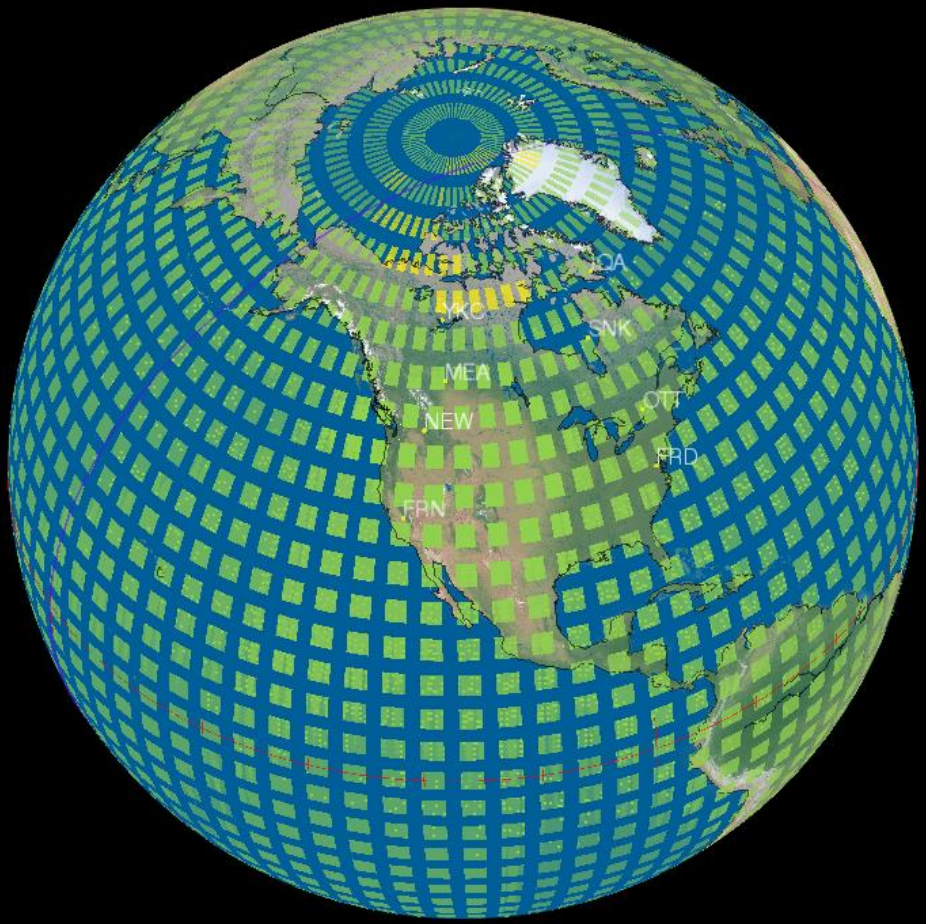

Current time : 2016-04-13 18:44:18 UT
Geospace : 2016-04-13 19:19:00 (35 mins ahead)
20
10
0
-10
-20
100.0
10.0
1.0
0.1
700
600
500
400
300
10^6
10^5
10^4
9
8
7
6
5
4
3
2
1
0
20
0
-20
-40
-60
Apr 11
Apr 12
Apr 13
Apr 14

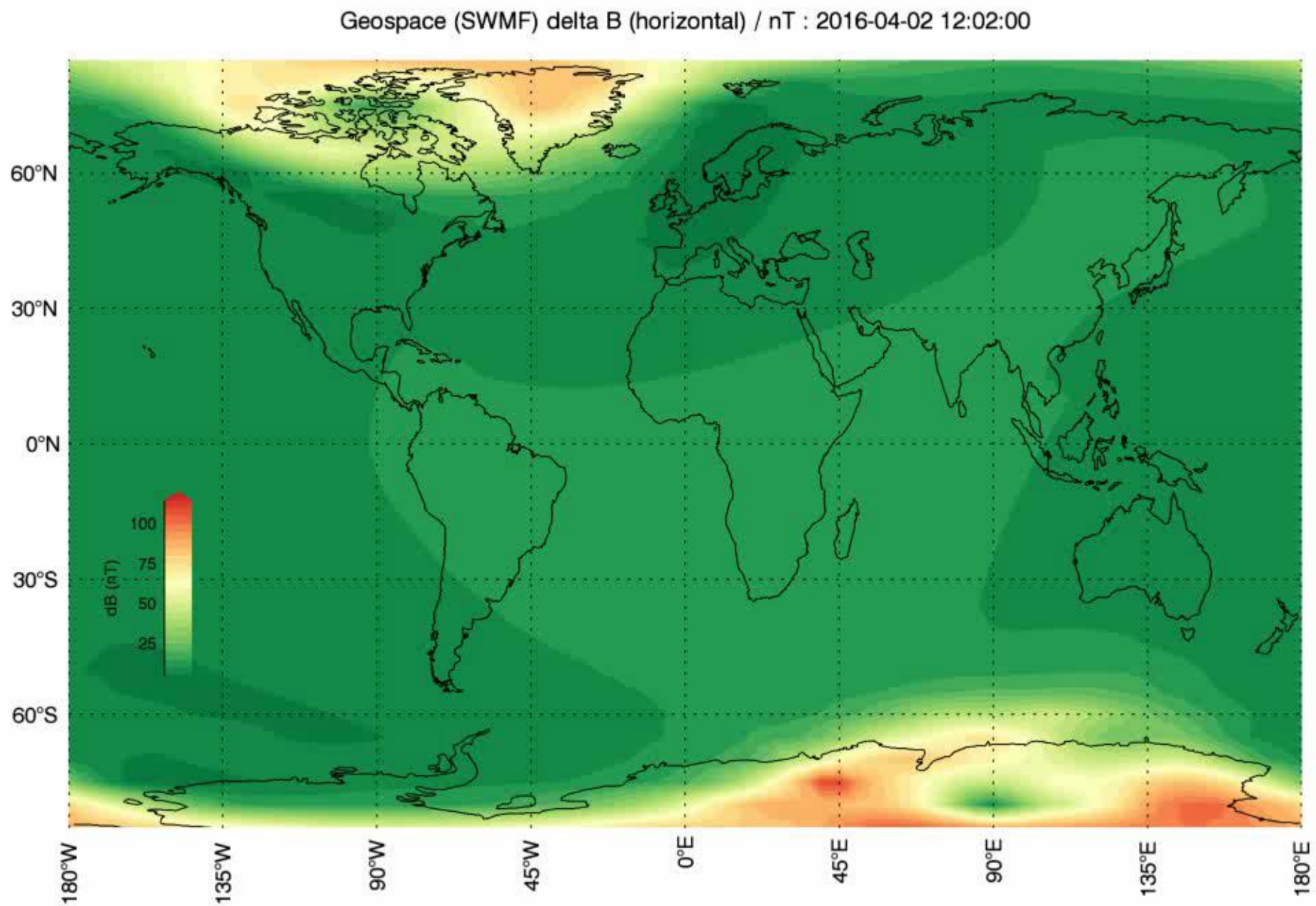
Initial Test Product : Local Time regional K prediction

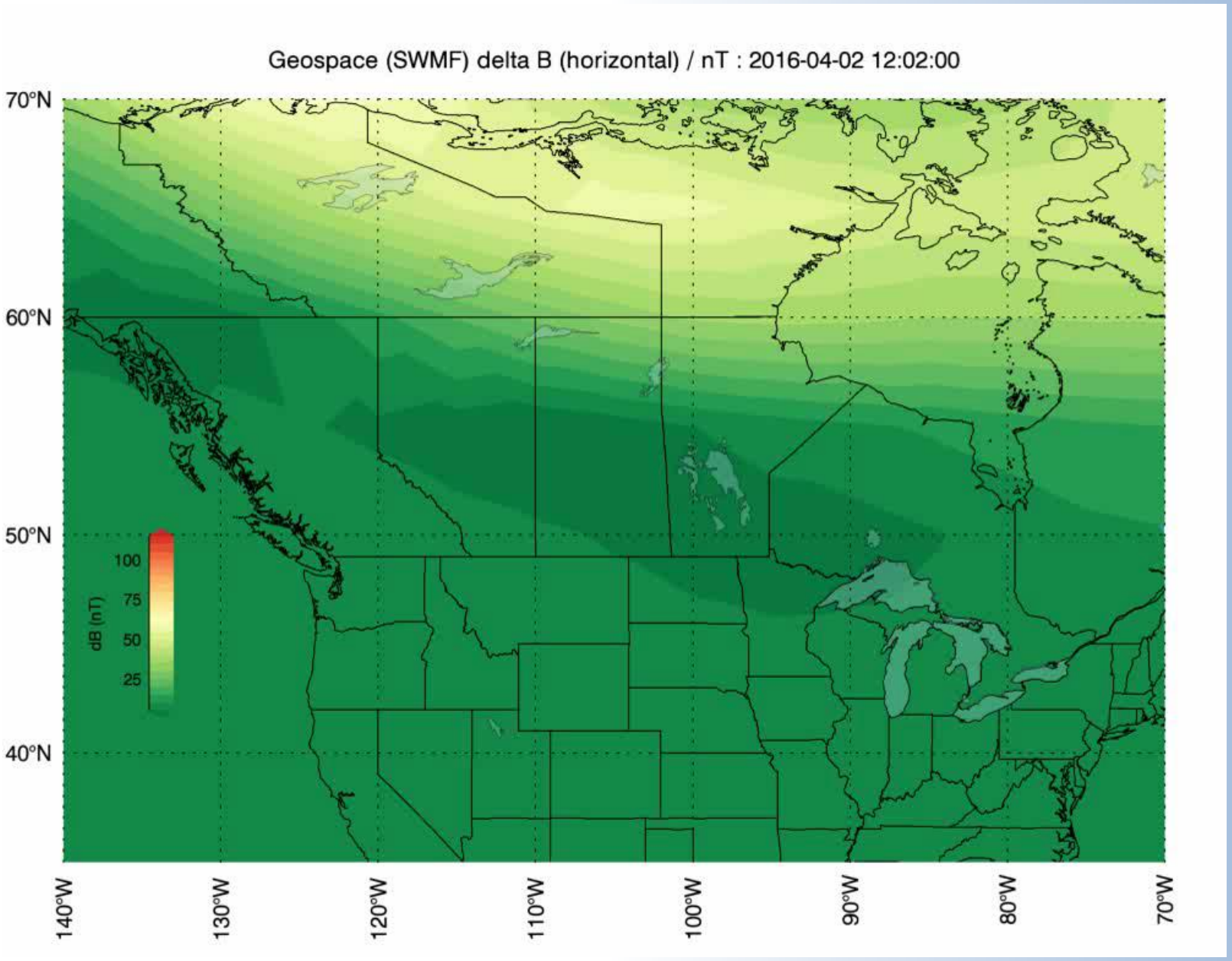




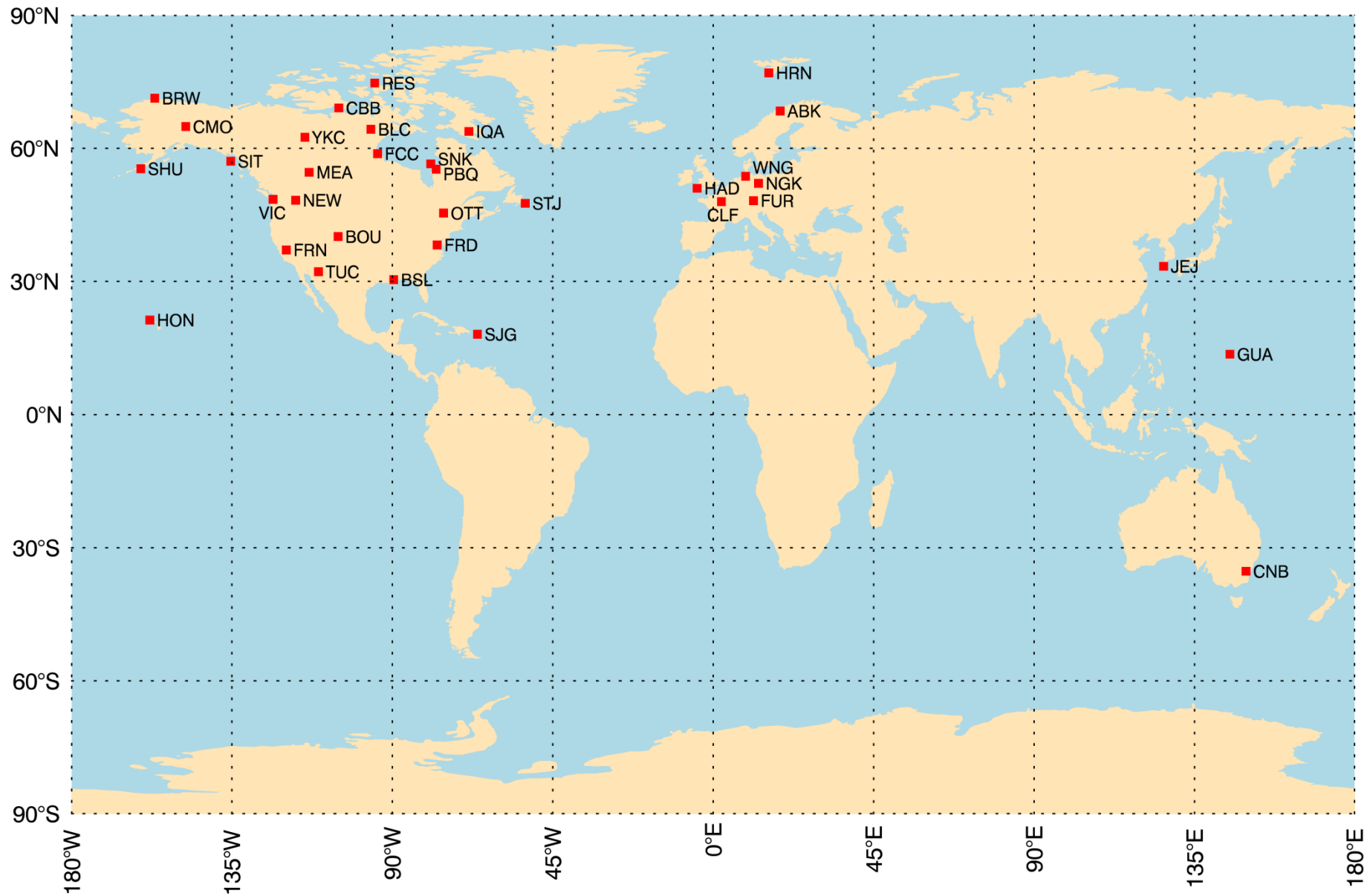
New Output: Global 5X5 Grid of Ground dB perturbations



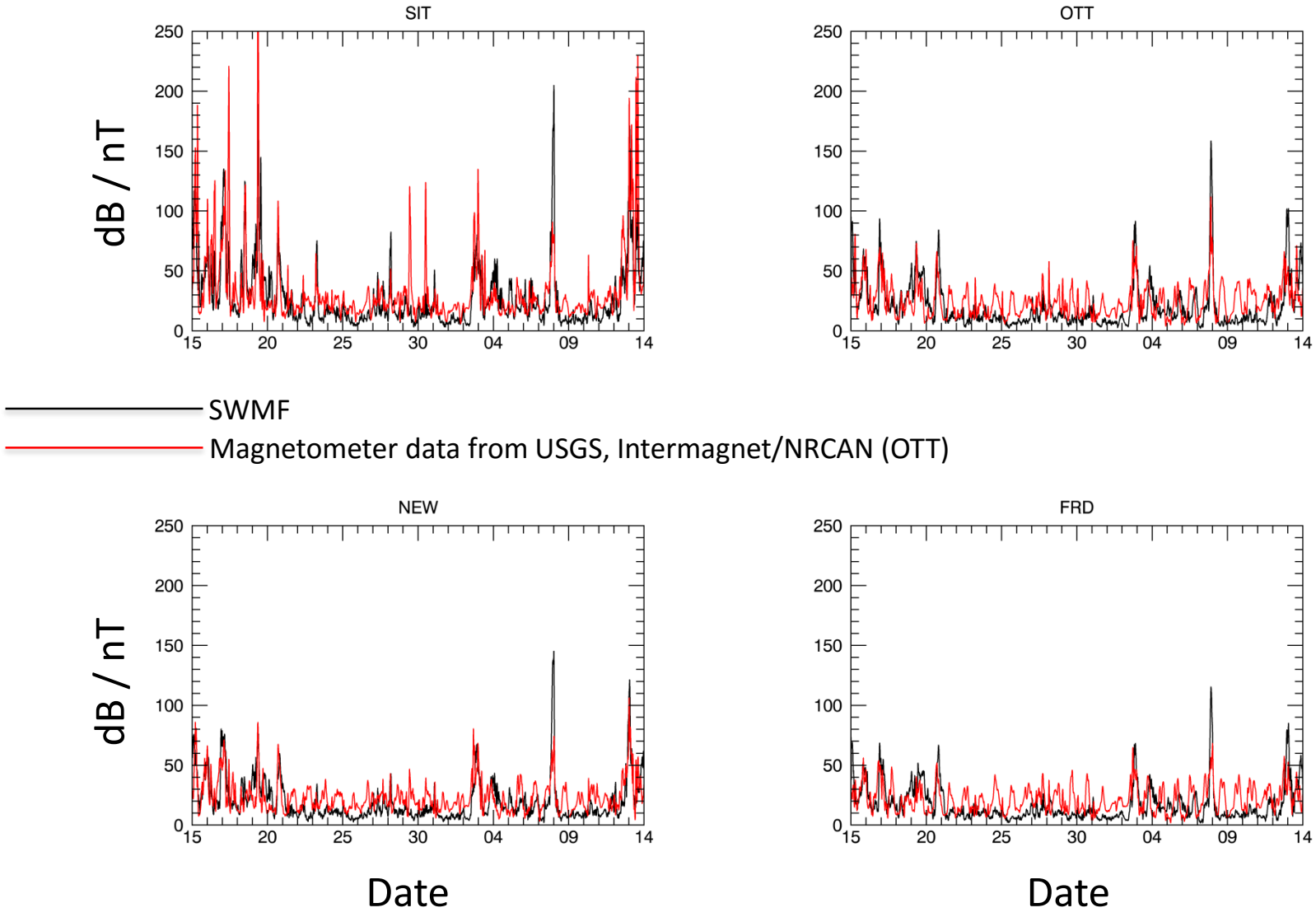

Geospace (SWMF) delta B (horizontal) / nT : 2016-04-02 12:02:00
60°N
30°N
0°N
30°S
60°S
100
75
50
25
dB (nT)
180°W
135°W
90°W
45°W
0°E
45°E
90°E
135°E
180°E


Geospace (SWMF) delta B (horizontal) / nT : 2016-04-02 12:02:00
70°N
60°N
50°N
40°N
140°W
130°W
120°W
110°W
100°W
90°W
80°W
70°W
dB (nT)
100
75
50
25

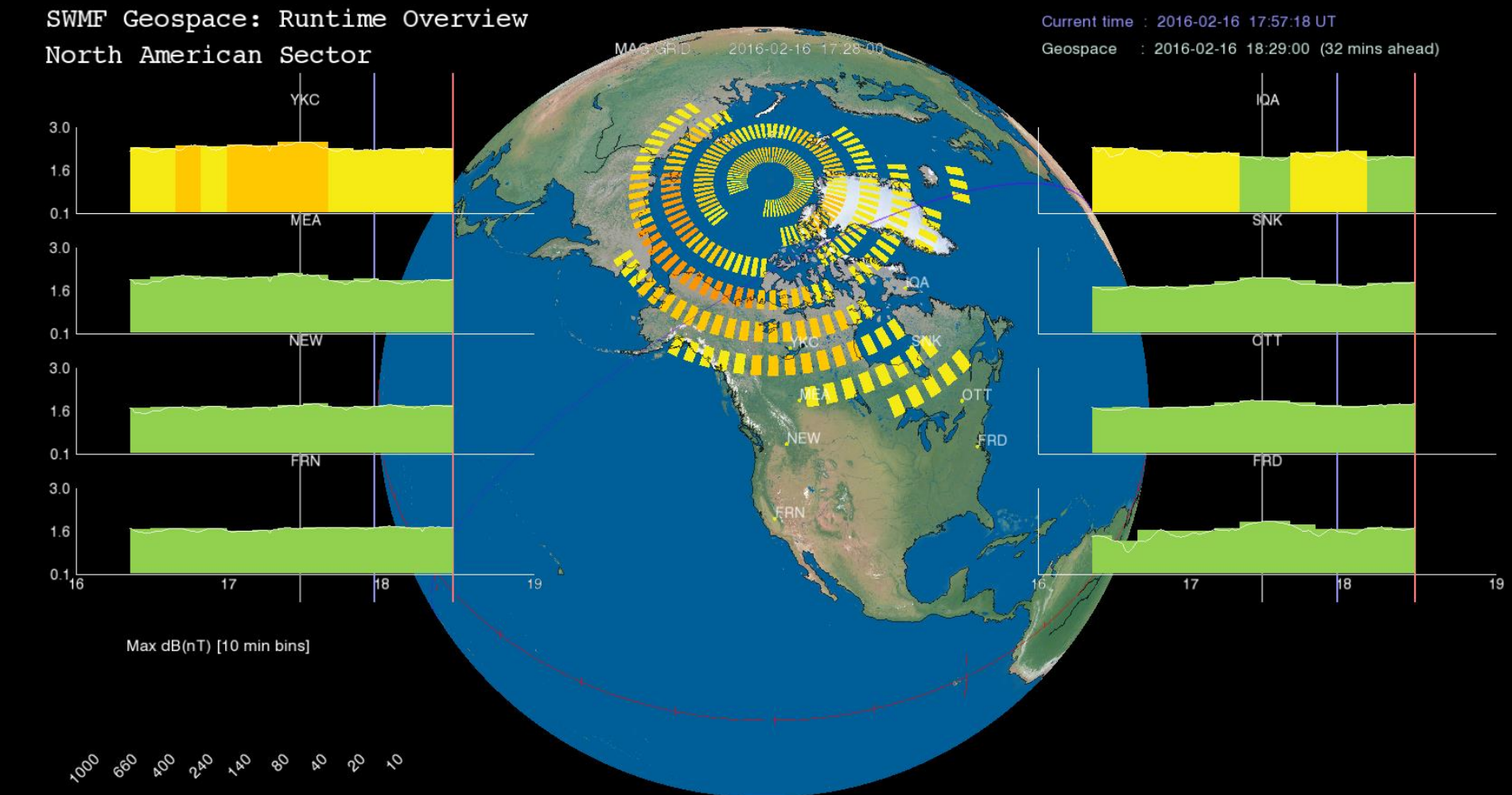
Specific Locations Defined Within the Geospace Model for Comparison with Real-Time Magnetometer Data



Model Validation underway (30 day test shown) – In Operations: Real-Time Validation



Product possibilities: Combining Global dB and location dB



Summary

- Solid collaboration with model developers at UMICH, benefits for both R2O and O2R. Also very solid relationship developed with System Production Analysts (SPAs) at NCEP/NCO
- Model system moved from /dev (SWPC) to /para (NCO SPAs) in January 2016
- Model currently running in /para. Completed NCEP 30 day evaluation on April 14th. Model system proved robust during computer switch, ACE data outage and SWPC move of all data and products to APS backup (Maryland). Presentation to NCEP director at the end of May. Model acceptance (hopefully) -> SWMF moved into /prod
- Initial array of forecast data products concerned with regional dB, dB/dt on both a global 5X5 grid and also at select magnetometer locations, regional K [LT], Kp, Dst,
- Fully Operational on October 1st, 2016. Graphic products at the SWPC website – data products via the SWPC data service. Later, Archived data via NCEI